

MARKSCHEME

May 2001

CHEMISTRY

Higher Level

Paper 3

OPTION C – HUMAN BIOCHEMISTRY

C1. (a) Chemical messenger / OWTTE **[1]**

(b) (i) Testes **[1]**

(Note: Do not award [1] for ovaries, since in humans the production of testosterone by the ovaries is extremely low in comparison with the testes.)

(ii) Use (e.g. treatment of wasting illness / to regain muscle tissue, treatment of eczema) **[1]**;

Abuse (e.g. increase muscle mass to enhance performance / increase strength) **[1]**;

Second use or second abuse **[1]**.

[3 max]

(c) Two groups circled correctly **[1]**;
Two correct corresponding names **[1]**.

Accept any two from the following:

- Alkanol / alcohol / hydroxyl;
- Alkene;
- Alkanone / ketone / carbonyl.

(Do not accept CH₃ / methyl / alkyl group or 'hydroxide')

[2 max]

(d) *Allow any one from:*

- Cholesterol has an OH group instead of the C = O group in testosterone;
- Cholesterol has an alkyl/hydrocarbon side-chain instead of the OH group in testosterone;
- There is no carbonyl group present in cholesterol;
- The position of the C = C bond is different in cholesterol compared to testosterone.

(Or any other correct answer, relating to structural differences.)

[1 max]

- C2.** (a) Glycerol / propane-1,2,3-triol (*accept correct structure*). [1]
- (b) Fatty acid(s) / salt of acid / soap / carboxylic acid / alkanoic acid / carboxylate. [1]
- (c) Heat with base / alkali / KOH / NaOH (*both needed*). [1]
- (d) Heat produced = (mass \times specific heat capacity $\times \Delta T$) (*can be scored by implication*) [1];
 = (500 \times 4.18 \times 67.5) [1];
 = 141.075 / 141075 J [1].

$$\text{Calorific value of bar} = \frac{50.0}{10.0} \times 141.075 ;$$

$$= 705.4 \text{ (kJ) / 705 (kJ) (accept correct value in J) [1].}$$

[4 max]

- C3.** (a) Hydrogen bond [1];
 Two H-bonds shown between T and A [1];
 Three H-bonds shown between C and G [1];
 Deoxyribose and phosphate (*both needed*) [1];
- Phosphate on one nucleotide bonds to (OH of) deoxyribose on the next nucleotide [1];
 - Condensation reaction / by covalent bonding [1].

[6 max]

- (b) Award [1] each for any four of the following points:
- Separate DNA from other material [1];
 - Cut DNA up (using restriction enzymes) [1];
 - Separate by electrophoresis [1];
 - Method of detection (*e.g.* UV, radioactive probe, X-ray) [1].

[4 max]

OPTION D – ENVIRONMENTAL CHEMISTRY

- D1.** (a) Water / CFCs / dinitrogen oxide (N_2O or nitrous oxide / O_3 / HCFCs / HFCs / SF_6). *[1]*
(Accept correct formula instead of a name).
- (b) (i) *Any two sources, [1] each*
e.g. Respiration (by animals) / decay of plants or animals / oxidation of soil humus / forest fires caused by lightning / volcanoes / combustion of fossil fuels and wood / burning trash (rubbish).
[2 max]
- (ii) *Any two sources, [1] each*
e.g. Bacterial fermentation / bogs or marshes / digestive tracts of ruminants. Rotting waste in land-fill sites.
[2 max]
- (c)
 - Lower energy / longer wavelength / infrared radiation from the Earth *[1]*;
 - Greenhouse gases absorb / retain / trap this energy *[1]*;
 - Some reference to how the gases absorb this energy *e.g. vibration [1]*.*[3 max]*
- D2.** (a) (i)
 - Solid objects / example of this (*e.g. rock*) *[1]*;
 - Grids / screens / sand bed (*do not accept filter*) *[1]*.*[2 max]*
- (ii)
 - Metal ions / phosphate *[1]*;
 - Alkali / sulfide / Ca^{2+} / calcium ions (accept a named calcium compound) *[1]*.*[2 max]*
- (b) (i) *Any two of the following [1] each*
 - Similar anti-bacterial action achieved with smaller $[\text{O}_3]$;
 - O_3 more effective than Cl_2 (against waterborne viruses);
 - O_3 imparts no chemical taste to water;
 - O_3 does not form harmful chlorine containing organic compounds.*[2 max]*
- (ii) O_3 must be produced on site (because of high reactivity) / O_3 has a shorter retention time. *[1]*

- D3.**
- NO_x produced in the exhaust gases **[1]**;
 - Sunlight converts the oxides of nitrogen into oxygen radicals (oxygen atoms) / $\text{NO}_x + \text{sunlight} \rightarrow \text{O}\cdot$ **[1]**;
 - The oxygen atoms react with hydrocarbons in the exhaust gases / $\text{O}\cdot + \text{HC} \rightarrow$ **[1]**;
 - This reaction produces alkanals **[1]**;
 - Which form PAN / peroxyacylnitrates **[1]**.

Any two of the following, [1] each

Cause irritation of the eyes / respiratory problems / damage to plants.

Numerous answers are possible here, all [1] each:

- Use catalytic converters which convert oxides of nitrogen into harmless nitrogen;
- Less car usage;
- Change to other fuels e.g. electric.

[10 max]

OPTION E – CHEMICAL INDUSTRIES

E1. (a) Heats the furnace / OWTTE [1].

Any valid reaction involving coke, *e.g.* reduces iron oxide / is converted to carbon monoxide [1].

[2 max]

(b) (i) Oxygen is blown through (the molten iron). (*Do not accept 'air' here*) [1];
It oxidises / converts the carbon into carbon dioxide gas (which escapes) [1].

[2 max]

(ii) Calcium oxide / lime is added (to the molten iron). (*Allow limestone*) [1];
Calcium oxide reacts (with the silica) to form calcium silicate / slag [1].

[2 max]

E2. (a) Any appropriate equation (*must have alkane and alkene as products*) [1];
One use of an alkane (*e.g.* fuel) [1];
One use of an alkene (*e.g.* polymer or name of polymer) [1].

[3 max]

(b) (i) Silica / aluminium oxide / zeolites.

[1]

(ii) **Heat** / high temperature / temperature above 300 °C ;

[1]

(c) Catalytic cracking produces a mixture of **alkanes and alkenes** [1];
Hydrocracking produces **alkanes** only [1].

[2 max]

E3. Any reasonable answer *e.g.* the products of refining are **flammable** and hence there is a risk of fire.

[1]

Any reasonable answer *e.g.* the gas produced in the furnace must not be released as it contains poisonous carbon monoxide.

[1]

E4. 1 mol(g) → 2 mol(g) so ΔS^\ominus increases / entropy change positive [1];
At higher T , ΔG^\ominus becomes more negative as $T\Delta S^\ominus$ becomes greater [1];

[2 max]

500 K $C \rightarrow CO_2$ more negative ΔG^\ominus

2000 K $C \rightarrow CO$ more negative ΔG^\ominus [1];

More negative ΔG^\ominus favoured [1].

[2 max]

- E5.** Cathode half-reaction: $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$ (*state symbols not needed*) [1];
Anode half-reaction: $2\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$ (*state symbols not needed*) [1];

[1] each for any **three** of the following:

Porous membrane;

Aqueous electrolyte / brine;

Positive electrode / anode: titanium graphite;

Negative electrode / cathode: steel.

Any reasonable advantage **and** disadvantage [1].

[6 max]

OPTION F – FUELS AND ENERGY

- F1.** (a) (i) 1 % **[1]**
- (ii) Inappropriate wavelengths **[1]**;
Reflected / heats the surface / not all areas covered by plants **[1]**.
[2 max]
- (b) (i) Photosynthesis. **[1]**
- (ii) $6\text{H}_2\text{O} + 6\text{CO}_2 \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$ **[1]**
(No marks if not balanced.)
- (c) (i) Any two of the following, **[1]** each
 - Combustion;
 - Production of biogas;
 - Production of ethanol / fermentation.**[2 max]**
- (ii) (Allow **[1]** for any reasonable advantage and **[1]** for any reasonable disadvantage.) **[2]**
- (d) (i)
 - Heat **[1]**;
 - Pressure **[1]**;
 - Absence of oxygen **[1]**.**[3 max]**
- (ii) Any three of the following, **[1]** each
 - Specific example of pollution (e.g. oil spills);
 - Cost of production / transport;
 - Non-renewable;
 - More valuable as a feedstock.**[3 max]**

- F2.** (a) Metals conduct electricity well, insulators do not, semiconductors are intermediate;
(Must have all 3 points for [2], 2 correct points for [1])

[2 max]

- (b) Converts solar energy to electricity *[1]*;
Si or Ge *[1]*;
Doped with group 5/As or other example *[1]*;
Doped with group 3/B or other example *[1]*;
Light stimulates electron flow *[1]*.

If mention n-type and p-type but do not explain, award only [1] of the [2] doping marks.

Any reasonable advantage **and** disadvantage *[1]*.

[6 max]

- (c) **voltage** depends on **materials** used *[1]*;
Power depends on the **quality** of materials *[1]*.

[2 max]

OPTION G – MODERN ANALYTICAL CHEMISTRY

G1. (a) Mass spectrometry. [1]

(b) Chlorine exists as **two isotopes**. [1]

(c) II: $^{37}\text{Cl}^+$ [1]

IV: $(^{35}\text{Cl} - ^{37}\text{Cl})^+$ [1]

[2 max]

(d) The ratio of the isotopes is 1:3 / 25 % ^{37}Cl and 75 % ^{35}Cl [1];
This is the ratios of the peak heights/intensities [1].

(Graph must be referred to for second mark.)

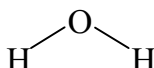
[2 max]

(e) (i) By bombarding with electrons. [1]

(ii) The molecular mass of the compound. [1]

G2. (a) **d to d** transitions / transitions within the **d** sub-level. [1]

(b) X-ray crystallography. [1]

G3. (a)  [1];

$\text{O}=\text{C}=\text{O}$ (accept linear shape without double bond) [1];

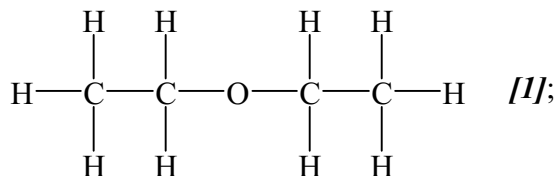
Bond length changes / stretching [1];

Bond angle changes / bending [1];

Dipole moment changes [1].

[5 max]

(b) (i) $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$ / ethoxyethane / diethylether [1];



• No broad band at $3230 - 2550 \text{ cm}^{-1}$ / no OH present [1];

• Therefore not alkanol or acid [1];

• No absorption $1680 - 1750 \text{ cm}^{-1}$ / C=O present [1];

• Therefore not acid or ester [1].

[6 max]

(ii) $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ has absorptions at $2500 - 3300$ and $1680 - 1750 \text{ cm}^{-1}$ [2];

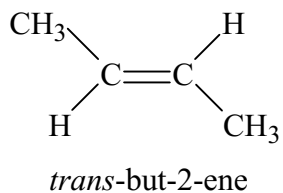
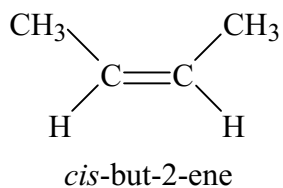
$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ has an absorption at $3230 - 3550 \text{ cm}^{-1}$ [1];

$\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_2\text{CH}_3$ has an absorption at $1680 - 1750 \text{ cm}^{-1}$ [1].

[4 max]

OPTION H – FURTHER ORGANIC CHEMISTRY

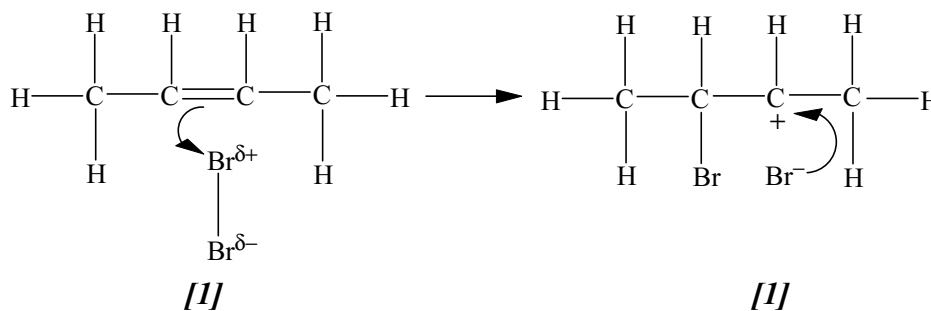
H1. (a) (i)



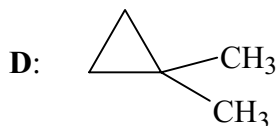
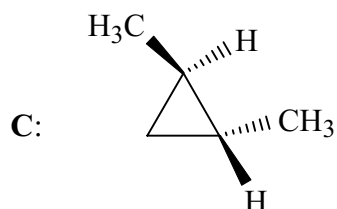
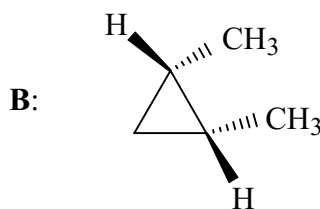
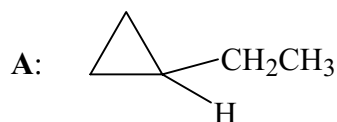
Each correct structure **[1]** each;
Both correct names **[1]**.

[3 max]

(ii)



(b) (i)



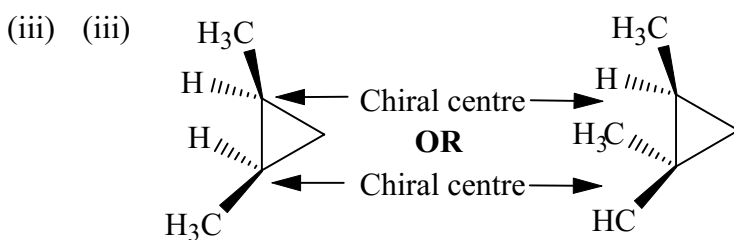
(Award **[1]** for each correct structure. Use ECF where possible if straight chain C₅ molecules given)

[4 max]

(ii) Structural: **A** and **D** / **A** and **B** / **A** and **C** / **B** and **D** / **C** and **D** **[1]**.

Geometrical: **B** and **C** **[1]**.

[2 max]



Correct structure [1].

Chiral centre marked [1].

[2 max]

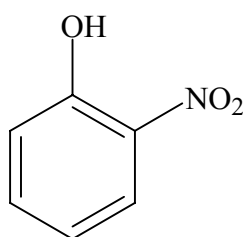
- (c) No rotation (in either but-2-ene or cycloalkanes) [1];
Without breaking the π component (in but-2-ene) and the ring (in cycloalkanes) [1];
(Both points are needed for the second mark here.)

[2 max]

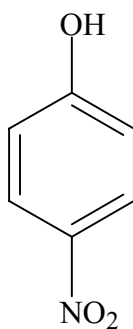
- (d) More strain / bond angles $< 109.5^\circ$.

[1]

H2. (a)

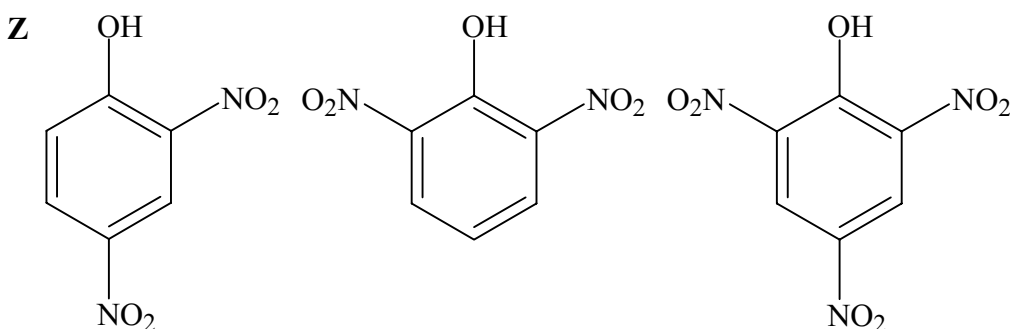


X



Y

Structures for nitrophenols, [1] each.



Structure for dinitrophenol/trinitrophenol (Only one of structures above is needed.) [1]

In phenol, lone pair of electrons on oxygen overlaps with delocalised ring [1].

Activates the ring / attracts electrophiles or NO_2^+ more strongly / increases electron density [1].

[5 max]

- (b) Nitro group is electron-withdrawing [1];
Bond polarity of O—H increased / more H^+ ions released [1];
Z has the most electron-withdrawing groups [1];
Correct reference to the stability of the anion [1].

[4 max]